A Study of Nucleon-Nucleon Interaction

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Abstract:

In the world there are so many work progress on Nucleon-Nucleon interaction. The researcher is very much interested to review regarding Nucleon-Nucleon interaction. Nucleon-Nucleon interaction is the most popular way of studying N-N interaction. The best way to do this is to observe two and three body interactions. Therefore the researcher study the two and three body kinematics in details. Nuclear reactions in which three particles are produced in the final state have recently become the subject of a good deal of experimental interest. The Kinematic formula which is relevant to nuclear reaction is shown here. Before going to discuss of three body kinematics, the researcher study the two body kinematics. The theory on two body kinematics is essential for studying three body kinematics. The different theoretical aspects regarding study on two body process of nuclear reaction is characterized. The researcher review the major progress of the past decade concerning about Nucleon-Nucleon interaction. The focus is on the low energy region. The researcher by using the c++ programme and also using three body kinematics nuclear reaction ,the graphical analysis is shown here.

Key words: Nucleon-Nucleon interaction, Two body kinematics, Three body kinematics, Nuclear force.

Introduction:

In the twenty first century in the world maximum number of nuclear Experimentalist worked on Nucleon-Nucleon interaction for determination of several properties of nuclear forces. The information found about nucleon-Nucleon interaction from scattering experiment is not complete. Therefore the researcher is very much interesting to study the different type of nuclear reaction by reviewing the past decade of nuclear physics. Today it is most important to calculate the different types of nuclear reaction by observing the output energies of the three outgoing particles from the there body kinematics. The researcher found the best technique is to study the three body kinematics. At first two body kinematics were studies and then the researcher study the three body kinematics. The theoretical aspects of two body kinematics of nuclear reaction was taken into consideration. Hence the conversation laws of energy and momentum for two body and three body kinematics are also taken into consideration. Nucleon-Nucleon interaction is studied traditionally through N-N scattering experiments. In such experiments scattering cross sections are experimentally measured and then compared to theoretical predictions to find the scattering amplitudes. The scattering amplitudes obtained through elastic scattering of two particles correspond to the on- the energy shell elements that is the diagonal elements of the transition matrix or in other words the elements of the scattering matrix.

Two body kinematics:

The motion of the colliding particles can be studied by taking the laws of conservation of energy and momentum. At first one has to consider the motion for two particles in which they collide to each other that is perform in different ways:

$$1+2 \rightarrow 1+2$$

The particle 1 is projectile and particle 2 is target. As before and after collision the particles are same so the process is known as scattering. Thus the scattering is said to be elastic if no energy is used in raising either of the particle to an excited state.

Three body kinematics:

The work continued on three body process. Nuclear reactions in which three particles are produced in the final state have recently become the subject of a good deal of experimental interest.

In general for three body kinematics,

A+(B+C) ->A+(B+C)

Here particle A hits the bound state (B+C) which is at rest and three particles A, B, C are the outgoing particles.

Nucleon-Nucleon scattering is the most popular way of studying N-N interaction. However off the energy shell matrix elements of N-N interaction can only be ascertained from nucleon break up reaction studies like N-D break up that is three particles are produced in the final state

The Kinematic equation which represent three body scattering is given by

p+d->p+p+n

Here p is proton which is projectile and d is the Deuteron which is target particles, outgoing scattered particles are proton, proton and neutron.

Objectives:

1. To study Nucleon-Nucleon interaction of three body kinematics.
2. To study the literature review on Nucleon-Nucleon interaction.
3. To study the energy locus due to change of different incident energies of projectile.

Related Reviews:

The alpha- neutron final state interaction

Alpha+Deuteron-> Alpha+Proton+Neutron break up reaction can be use for observing off energy shell behaviour. For this different chosen pair of correlation angles for outgoing alpha and proton particles. Now these sets are allowed phase spaces are in favour of the alpha-neutron final state interaction. The alpha induced break up experiment help us to understand the nature of nuclear force, particularly to find whether there is any effect of three- body interaction in the nuclear force. Below the alpha break up threshold, there are three particles I. e. alpha, proton neutron and both two body and three body interactions in the final state are possible. A great deal of effort has given to study the FSI, in alpha - Deuteron break up.

Koersner (1977) studied the alpha- deuteron break up reaction for eleven correlation angles. He analysed the data in semi phenomenological impulac approximation. The discrepancies between theoretical fit and the experimental data were explained by the prediction of triton transfer reaction.

Glantz (1977) observed interference between alpha - neutron and alpha -proton FSI in the same configuration in a Kinematically complete experiment incident energies of alpha particles are 13 Mev, 15 Mev, 18 Mev.

Y. Koike (1978) explain the discrepencies as due to a large interference between alpha-neutron and alpha-proton FSI

Rausch (1974) studied the reaction ^{2}H ($_\alpha$, αP) reaction at incident energies E_α = 21.9MeV and 23.7 MeV also kinematically complete experiment suitable for observing αP QFS and nP FSI their observtion however showed that αP FSI and QFS along with the nP

Dasgupta (1980) studied FSI in the alpha induced deuteron break up at a fixed corelation angle for the outgoing proton and alpha particles $\theta_\alpha=15^0$, $\theta_p=30^0$. however he observed overlapping of different FSI (αP and αN) and αP quasifree scattering. the overlapping of different phase spaces was due to low kinematic energies of the outgoing particls at E_α = 15MeV energy.

Bruno (1980) studied the deuteron breakup reaction at incident alpha particle energies between 9.847 and 13.991MeV for 21 correlation angles. the data were compared with the predictions based on Faddeev equations. he observed interference between (αP and αN) FSI. the interference was due to low kinetic energies which produced small kinematical loci.

Warner and Bercaw (1980) studied the above reaction at higher incident energies E_α = 42MeV. and at several corelation angles to observe the αN FSI. They observed prominent peak due to helium and lithium FSI.

De (1995) using 45 MeV for the incident alpha particle, reported three body effect in the nuclear force from their measured cross section at one pair of correlation angles $\theta_\alpha=20^0$, $\theta_p=54^0$. Therefore off-the energy shell matrix elements this FSI in allowed phase space are observed.

Methodology:

Nuclear reactions in which three particles are produced in the final state the observed output energies plotted in the graphical distribution. here when two detectors are used in coincidence at aparticular pair of angles the particle energy will be determined fully from momentum and energy conservation equations.

Thus the allowed laboratoty energies E_1^l , E_2^l satisfy the equation will be $1/M_3[E_1^l(M_1+M_3)+E_2^l(M_2+M_3)-2(E_p^l E_1^l M_1 M_p)^{1/2}\cos\theta_1^l-2(E_p^l E_2^l M_1 M_p)^{1/2}\cos\theta_2^l+2(E_1^l E_2^l M_1 M_2)^{1/2}\cos\theta_{12}^l]=Q+E_0^l(1-M_p/M_3)$

Where, M_p is the mass of projectile

M_1 is the mass of first out going particle

$M_2$is the mass of second out going particle

$M_3$is the mass of third out going particle

E_1 is the energy of first out going particle

$E_2$is the energy of second out going particle

E_p is the energy of projectile

$Q=(M_1+M_2)/M_2\times$ BE

BE is the binding energy of the target particle

θ_1 is the polar angle of the first outgoing particle

θ_2 is the polar angle of the second outgoing particle

φ_1 is the azimuthal angle of the first outgoing particle

φ_2 is the azimuthal angle of the second outgoing particle

$\cos\theta_{12}^l=\cos\theta_1^l\cos\theta_2^l+\sin\theta_1^l\sin\theta_2^l\cos(\varphi_1-\varphi_2)$

For convenience, centre of two detectors and the direction of the incident are set to be coplanar so that the azimuthal angles (φ_1,φ_2) of the two out going particle share automatically set at 0^0 and 180^0

Results and Discussion:

Kinematic loci for p-d system

The proton induced deuteron break up is given by ,$p+d \rightarrow p+p+n$

The kinematic energy gives the variation of proton energies with out going proton energies. This energies locus,

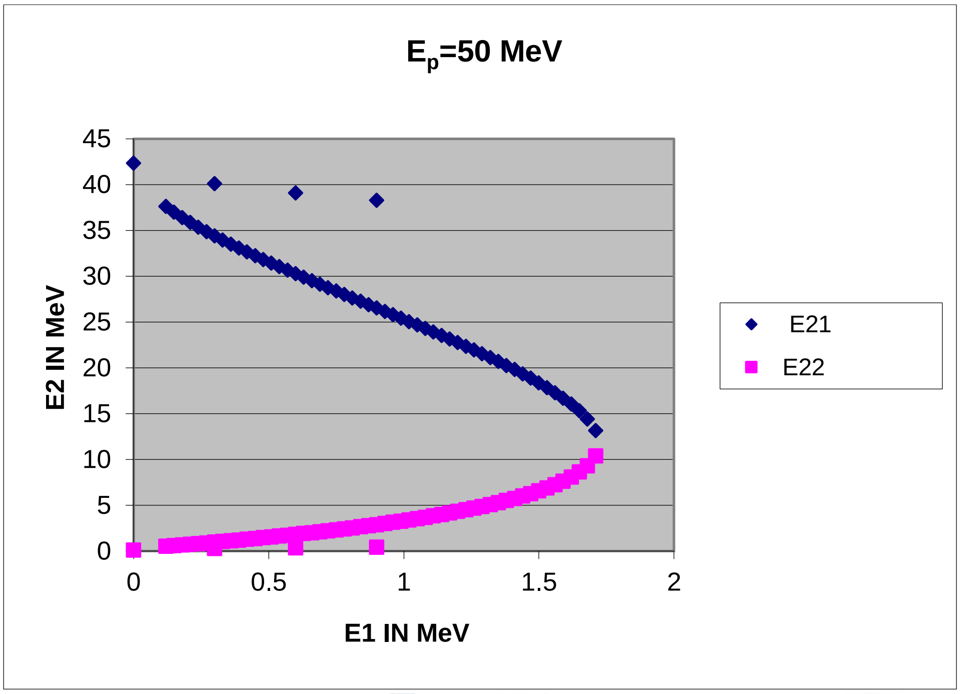
i) Changes due to different incident energies.

ii) Changes due to different angular correlations.

The following cases are investigated by the researcher, using the C++ programme for three body kinematics.

Data for Proton induced deuteron breakup by using C++ Programme.

Sl. No.	E1	E21	E22	Sl. No.	E1	E21	E22
1	0	42.34290409	0.115952892	30	0.869999647	26.89213173	2.761908188
2	0.299999993	40.07684984	0.267323473	31	0.899999619	26.52299213	2.881891924
3	0.599999987	39.07731316	0.355784281	32	0.92999959	26.15341383	3.005439296
.4	0.899999961	38.28411771	0.435924091	33	0.959999561	25.78303869	3.13276194
5	0.119999997	37.59677466	0.512713986	34	0.989999533	25.41150201	3.264089908
6	0.149999991	36.97640188	0.588042094	35	1.019999504	25.0384049	3.399679577
7	0.179999992	36.4030613	0.66286697	36	1.049999475	24.6633638	3.539813049
8	0.209999993	35.8649093	0.7377594	37	1.079999447	24.2859404	3.684803786
9	0.239999995	35.35423105	0.813096678	38	1.109999418	23.90569152	3.835003767
10	0.269999981	34.86565432	0.889148764	39	1.13999939	23.5221198	3.990806623
11	0.299999982	34.39524674	0.966121866	40	1.169999361	23.1346958	4.152659263
12	0.329999983	33.94005608	1.0441813	41	1.199999332	22.74282029	4.321069294
13	0.359999985	33.49774931	1.123466697	42	1.229999304	22.34583407	4.496617691
14	0.389999986	33.06648123	1.204099846	43	1.259999275	21.94299656	4.67997949
15	0.419999987	32.64473637	1.286191913	44	1.289999247	21.53344873	4.871937297
16	0.449999988	32.23124774	1.369845982	45	1.319999218	21.11620543	5.073414957
17	0.479999989	31.8249566	1.455160026	46	1.349999189	20.69009777	5.285512932
18	0.509999991	31.42494188	1.54223144	47	1.379999161	20.25374668	5.509558987
19	0.539999962	31.03041067	1.631154841	48	1.409999132	19.80546487	5.747183346
20	0.569999933	30.64066276	1.722027017	49	1.439999104	19.34316528	6.000416255
21	0.599999905	30.25507758	1.814946974	50	1.469999075	18.8642123	6.271849861
22	0.629999876	29.87309104	1.910015846	51	1.499999046	18.36516328	6.56487897
23	0.659999847	29.49418901	2.007339192	52	1.529999018	17.84137821	6.88409519
24	0.689999819	29.11790598	2.107027531	53	1.559998989	17.28633499	7.235978453
25	0.71999979	28.74379836	2.209197518	54	1.58999896	16.69032258	7.630202583
26	0.749999762	28.37145937	2.3139731	55	1.619998932	16.03768085	8.082386993
27	0.779999733	28.000493	2.421485086	56	1.649998903	15.29995517	8.620950656
28	0.809999704	27.63052412	2.53187569	57	1.679998875	14.41344278	9.309561934
29	0.839999676	27.26118825	2.645295209	58	1.709998846	13.14202688	10.38429936



From the graphycal statement it has been seen that the kinematic loci under the condition $\theta_1=10^0=\theta_2$, **E_p=50 MeV,** allowed curves corresponding to a pair of out going particals become larger as incident energy increases.

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